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STINSON, FRANKIE L	

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BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

Application Number: 10/051,860
Filing Date: January 16, 2002
Appellant(s): BERGMAN, ERIC

Kenneth H. Ohriner
For Appellant

EXAMINER'S ANSWER

This is in response to the appeal brief filed January 17, 2006 appealing from the Office action mailed July 28, 2005.

(1) Real Party in Interest

A statement identifying by name the real party in interest is contained in the brief.

(2) Related Appeals and Interferences

The examiner is not aware of any related appeals, interferences, or judicial proceedings which will directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal.

(3) Status of Claims

The statement of the status of claims contained in the brief is correct.

This appeal involves claims 1, 5-10, 12-18 and 33-35.

(4) Status of Amendments After Final

The appellant's statement of the status of amendments after final rejection contained in the brief is correct.

No amendment after final has been filed.

(5) Summary of Claimed Subject Matter

The summary of claimed subject matter contained in the brief is correct.

(6) Grounds of Rejection to be Reviewed on Appeal

The appellant's statement of the grounds of rejection to be reviewed on appeal is correct.

(7) Claims Appendix

The copy of the appealed claims contained in the Appendix to the brief is correct.

(8) Evidence Relied Upon

5,181,985 Lampert et al. 1-1993

5,868,866	Maekawa et al.	2-1999
5,927,306	Izumi et al.	7-1999
6,202,658	Fishkin et al.	3-2001
6,325,081	Miki et al.	12-2001
6,758,938	Torek et al.	7-2004
1-95522	Kobayashi (Japan)	4-1989

(9) Grounds of Rejection

The following ground(s) of rejection are applicable to the appealed claims:

Claims 1, 4-10, 12-18 and 33 are rejected under 35 U.S.C3. 103(a) as being unpatentable over Torek et al. (U. S. Pat. No. 6,758,938) in view of Japan 1-955222 (Japan'522), Izumi et al. (U. S. Pat. No. 5,927,306), Miki et al. (U. S. Pat. No. ,325,081) or Fishkin et al. (U. S. Pat. No. 6,202,658).

Re claim 1, Torek is cited disclosing an apparatus for processing a workpiece comprising:

a liquid supply source (pool 95);

one or more liquid outlets (75) disposed to apply a layer of liquid onto the workpiece (see col. 2, lines 46-57);

a liquid flow line (see fig 2) extending between the liquid supply source and the one or more liquid outlets for carrying liquid to the liquid outlets;

at least one heater (45) for heating the liquid before it is applied onto the workpiece;

an ozone gas supply system (as at 100) which provides ozone gas around the workpiece (see abstract) while the layer of heated liquid is on the workpiece that differs from the claim only in the recitation of the a sonic energy source associated with the liquid outlets for introducing sonic energy to the workpiece through the layer of liquid on the workpiece. Japan'522, Izumi, Fishkin and Miki are each cited disclosing that it is very old and well known to in the art of processing semiconductor workpieces, to have sonic energy associated with water-filled baths, supports and nozzle outlets for applying sonic energy waves for intensifying the cleaning or other processes. It therefore would have been obvious to one having ordinary skill in the art to modify the outlets of Torek, to include sonic energy associated therewith, for the purpose of enhancing the cleaning process. It has long been recognized in various arts that the application of sonic energy to a gas, liquid, supports or tanks, increases the effectiveness of the desired process. Miki for example teaches that suggests that by applying high frequency sound waves it is possible to "increase the washing effects" and to "shorten washing time" (see Miki col. 6, lines 64-67). Re claim 4, Torek, as proposedly modified, discloses the sonic energy source associated with the liquid outlets as claimed. Re claim 5, Izumi discloses the focusing chamber for the sonic energy. Re claim 6, to have the heater, heating the reservoir is deemed to be an obvious substitution of equivalents (see MPEP 2144.06 SUBSTITUTING EQUIVALENTS KNOWN FOR THE SAME PURPOSE. Re claim 7, Torek, Japan'522 and Miki disclose the liquid as claimed. Re claim 8, Torek, Izumi and Miki disclose the chamber. Re claim 9, Torek discloses the re-circulation as claimed. Re claim 10, Torek discloses the rotor (see fig. 5). Re claim 11, Torek, Japan'522, Fishkin,

Izumi and Miki disclose the nozzles as claimed. Re claims 12-14, Torek discloses the controlling of the layer thickness (see col. 2, lines 46-57). Re claim 15, Torek discloses the controlling of the thickness as claimed (see col. 9, lines 9-11).

Re claim 16, Torek is cited as applied above disclosing an apparatus for treating the surface of a workpiece comprising:

a liquid reservoir for holding a process liquid;

a process chamber;

a workpiece holder (85) within the process chamber;

liquid spray nozzles (75) within the process chamber disposed to spray liquid onto the workpiece held by the workpiece holder;

a liquid flow line extending between the liquid reservoir and the liquid spray nozzles;

an ozone generator (see col. 6, lines 25-30) for generating a supply of ozone;

one or more ozone supply lines (not shown) extending from the ozone generator to the process chamber;

at least one heater for heating the process liquid,

that differs from the claim only in the recitation of the sonic energy source on the workpiece holder for introducing sonic energy to the workpiece. Japan'522 is cited disclosing that it is old and well known to provide a workpiece holder (see fig. 4) where there is provided a sonic energy source, for introducing sonic energy to the workpiece. It therefore would have been obvious to one having ordinary skill in the art to modify Torek, to include a sonic energy source as taught by Japan'522, for the reasons as

previously stated in paragraph 2 above. Re claim 19, Japan'522, Fishkin, Izumi and Miki all disclose the horizontal orientation of the workpiece as claimed. It therefore would have been obvious to one having ordinary skill in the art to modify the orientation of the workpiece in Torek, to have and horizontal orientation as taught by Fishkin, Izumi and Miki, since Torek discloses that a "wide variety of rotating mechanisms could be used" (col. 8, lines 61-67). Re claim 18, Torek discloses the spent fluid valve (65).

Claim 35 is rejected under 35 U.S.C. 103(a) as being unpatentable over Lampert et al. (U. S. Pat. No. 5,181,985) in view of Maekawa et al. (U. S. Pat. No. 5,868,866). Re claim 35, Lampert is cited disclosing chamber;

apparatus comprising:

a chamber (col. 3, line 62-63);

a rotor in the chamber for holding and rotating a workpiece (col. 6, line 8);

a liquid supply source (col. 2, line 33);

a liquid outlet positioned to apply a liquid onto a ,workpiece in the chamber;

a liquid flow line connecting the liquid supply source to the liquid outlet (col. 2, lines 40-51);

a heater for heating the liquid (col. 2, lines 33-39);

an ozone gas generator (col. 5, lines 55-57);

an ozone gas supply line connecting the ozone gas generator to the chamber (col. 5, lines47-53) that differs from the claim only in the recitation of the sonic energy source associated with the liquid outlet, and positioned adjacent to the

workpiece for introducing sonic energy to the workpiece, with the sonic energy conducted to the surface of the workpiece through liquid flowing out of the liquid outlet. The patent to Maekawa is cited disclosing the sonic energy source as claimed. It therefore would have been obvious to one having ordinary skill in the art to modify the device of Lampert, to employ sonic energy as taught by Maekawa, for the purpose of enhancing the cleaning effect as is old and well know in the art.

(10) Response to Argument

Applicant primarily argues that the application of the liquid in Torek, is in the form of a spray and therefore, not applicable with the respective teachings of Izumi, Fishkin, Miki or Japan'522/Kobayashi, since as argued to be well known, that sonic energy cannot travel through a spray, be cause a spray is not an incompressible fluid, i.e., it is not solid or a continuous liquid. It should be noted that while Torek discloses a spray, it is the examiner position that it would have been obvious to one having ordinary skill in the art to have the spray in Torek associated with sonic energy as taught by Izumi, Fishkin, Miki of Japan'522/Kobayashi, since Izumi (at col. 7, lines 32-52 and col. 3, lines 49-58), Fishkin (at col. Col. 1, lines 21-32), Miki (at col. 19, lines 31-45) and Japan'522/Kobayashi (see fig. 4) all disclose the spraying of the liquids and fluids. It should be noted that the examiner has used the Applicant's specification to specifically define the application of the liquid of Applicant's invention where Applicant has also define the sonic liquid application as "sprayed" as at paragraph [0006], line 5 "controlled spray"; at paragraph [0021], lines 4-5 "flows or sprays out through the nozzle" and in

claims 16, lines 4-7. Also noted that Applicant argues a "fluid link" between the nozzle and the wafer, but no specific limitation has been claimed.

As for the argument that Fishkin fails to disclose the claimed fluid layer, please note the Fishkin was only cited to discloses the obvious of employing sonic energy to a spray nozzle for enhanced cleaning as is common in the art. Torek discloses the layer as claimed (see abstract). As for Miki not disclosing the use of ozone, this teaching may be found in the disclosure of Torek. Miki was only cited to disclose the application of sonic energy to a spray nozzle as noted above. As for the argument in that any ozone in Mike would be separated by the sonic energy, please note that this is deemed immaterial in that in the disclosure in Torek, discloses two methods of providing ozone (see abstract) where the ozone may be applied either mixed with the fluid spray prior to spraying or unmixed but provides an "ozone-rich environment" and the workpiece is then sprayed (abstract). The individual use of ozone and sonic energy to treat semiconductor wafer are both old and well known. It is the examiner position that given the respective teachings of Torek, and either Izumi, Fishkin, Miki or Japan'522, especially where Torek teaches the use of ozone either mixed with the liquid prior to spraying, or not mixed with the water spray, it would have been obvious to modify Torek to employ sonic energy an enhanced cleaning effect as is old and well known in the art. As for the argument that Lampert fails to disclose the incompressible media as claimed, note the use of either an "aerosolized" medium and or the medium being "sprayed' (col. 2, lines 40-46) and again, as defined in Applicant's specification as noted above, the medium is sprayed as well.

For the above reasons, it is believed that the rejections should be sustained.

Respectfully submitted,

FRANKIE L. STINSON
Primary Examiner
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PTO 03-2652

Japanese Kokai Patent Application
No. Hei 1[1989]-95522

DRYING APPARATUS

Akio Kobayashi

UNITED STATES PATENT AND TRADEMARK OFFICE
WASHINGTON, D.C. APRIL 2003
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DRYING APPARATUS

[Kanso sochi]

Inventor:	Akio Kobayashi
Applicant:	KK Pre-tech

[There are no amendments to this patent.]

Claim

Drying apparatus characterized in that it is equipped with: a fixed base for affixing the substrate material to be cleaned with ultrapure water, a vibrator disposed on the reverse surface of the fixed base, an oscillator for driving the vibrator, and a nozzle that is disposed above the aforementioned fixed base to blow gas on the surface of the substrate affixed to said fixed base.

Detailed explanation of the invention

This invention relates to an apparatus used for drying of substrates (for example, silicon wafers, which are LSI substrates, or the photomasks used in the LSI element formation process for said wafers) where a high degree of cleanliness is required after washing.

Prior art

For example, silicon wafers used to manufacture semiconductor devices are usually cut [from] silicon ingots, mirror polished, immersed in a processing tank that contains hydrofluoric acid or nitric acid, then washed with ultrapure water, and also submitted for element formation after being dried. These silicon wafers are also subjected to drying after washing with ultrapure water in the process for forming LSI elements, etc.

So as drying apparatuses used after the aforementioned washing with ultrapure water, the structures explained below are already known.

(1) A so-called spin drying apparatus that is equipped with a rotary base that rotates at high-speed. The substrate (wafer, etc) after washing is affixed on said rotary base, the rotary base is rotated at high speed, and the water on the substrate surface is separated and removed to dry it.

(2) A so-called gas knife type cleaning apparatus where a nozzle that has a long, narrow nozzle opening that blows high-pressure gas is disposed above the fixed base, the substrate (wafer, etc.) after washing is affixed on said fixed base, said nozzle is moved over the top of the substrate while high-pressure gas is blown from the aforementioned nozzle, and water on the substrate surface is separated and removed to dry it.

(3) A so-called vapor drying apparatus with a heating means is furnished in a treatment tank that contains isopropyl alcohol (IPA). The substrate (wafer, etc.) after washing is placed in the top part of said treatment tank so that the clean surface faces the IPA on the inside, and the water on the substrate surface is replaced by IPA, which is then vaporized by the heating means, and is removed and dried.

Problems to be solved by the invention

However, with the aforementioned spin drying apparatus in (1), the rotary base is rotated at a high speed of 2000-5000 rpm and the moisture on the substrate on said rotary base is separated and removed. So the problem has been that the flying water strikes the cylindrical hood placed around the periphery of said rotary base and splashes back, and it re-adheres to the substrate surface, causing contamination. Making the distance between the rotary base and the hood large enough to avoid this to prevent the aforementioned substrate contamination has been considered, but this causes a new problem, namely, the apparatus will become bigger. With the aforementioned gas knife type drying apparatus in (2), the problem has been that, not only does the same type of substrate contamination as in aforementioned (1) occur, but static electricity is generated by friction of the high-pressure gas and the substrate, and particles of impurities in the gas adhere to the substrate surface, causing contamination. With the aforementioned vapor drying apparatus in (3), toxic, highly flammable IPA is used, so there would be problems such as

deterioration of the work environment and concerns about fire, and in addition, pollution caused by discharge of used IPA.

This idea was devised to solve the aforementioned problems. It will provide a compact drying apparatus that can sufficiently remove water on the substrate surface to make it highly clean as well as preventing contamination caused by water splash back.

Means to solve the problems

The present invention is a drying apparatus that is characterized in that it is equipped with a fixed base for affixing the substrate material to be cleaned with ultrapure water, a vibrator disposed on the reverse surface of the fixed base, an oscillator for driving the vibrator, and a nozzle that is disposed above the aforementioned fixed base to blow gas on the surface of the substrate affixed to said fixed base.

Operation

With this invention, water on the substrate surface can be removed just by blowing gas from a nozzle at a pressure one magnitude lower than the high-pressure gas in a conventional gas knife type drying apparatus by combining atomizing of the water on the surface of the substrate affixed on said fixed base using a vibrating plate disposed on the reverse surface of the fixed base, and a nozzle disposed above said fixed base to blows gas. The result is that, as already stated, it is possible to obtain a compact drying apparatus that can sufficiently remove water on the substrate surface to provide a high [degree of] cleaning, and also prevent contamination by water splash-back.

Application examples of the invention

Below, an application example of this invention will be explained in detail by referring to Figures 1 and 2.

(1) in the figures is a cylindrical fixed base that has vacuum chuck part (2) at the top. Vacuum tube (3), that communicates with a vacuum pump which is not shown, is connected in the center of the reverse surface of vacuum chuck (2) of fixed base (1). A plurality of vibrators (4), for example, four, is also disposed on the reverse surface of aforementioned vacuum chuck part (2). These vibrators (4) are formed from ceramic piezoelectric elements with a resonating frequency of 800 kHz, for example. Each of the aforementioned vibrators (4) is connected to oscillator (6) by cable (5). In addition, nozzle (7) that can move in the direction of the arrow is disposed above aforementioned fixed base (1). Nozzle (7) is constituted with nozzle unit (8), that is disposed at a desired angle of inclination relative to aforementioned fixed base (1), has a pair of opposing side walls that are tapered and form a rectangular tube shape, and has a long, narrow nozzle opening for

blowing gas (for example, air) to the tip of said tapered part, and gas introduction pipe (9) that is connected to the top wall on the opposite side from the aforementioned nozzle in nozzle unit (8). Here, a cylindrical hood, which is not shown, is furnished around the periphery of aforementioned fixed base (1).

Next, the operation for drying a silicon wafer, which serves as the substrate and has been sliced from a silicon ingot, mirror polished, and has water adhered to the surface after washing with ultrapure water, with a drying apparatus constituted as described above will be explained. First, after silicon wafer (1) is mounted on vacuum chuck part (2) of fixed base (1), said wafer (10) is suction chucked by said chuck part (2). Next, vibrators (4) vibrate when 800 kHz high frequency is applied to vibrators (4) through cable (5) from oscillator (6). High-frequency vibration is transmitted to wafer (10), which is vacuum chucked to fixed base (1) with vibrators (4) disposed on the reverse surface, by this, and water (11) adhered to the surface of said wafer (10) is atomized. In this state, when air, for example, is introduced into nozzle unit (8) that is inclined relative to fixed base (1) through gas introduction pipe (9) of nozzle (7) and it is moved and scanned from one end above wafer (10) toward the other end while blowing into the atomized water on wafer (10) from the long-narrow nozzle opening in said unit (8), the atomized water will be removed and drying accomplished. At this time, water (11) adhered to the surface of wafer (10) is atomized by the aforementioned vibrators (4), so air blown toward said wafer (10) through nozzle (7) will remove water (11) on the surface of wafer (10) with pressure (for example, 1-3 m/sec) that is one magnitude or more lower than the high-pressure gas jet (air speed 10 – 30 m/sec) of a conventional gas knife type.

Thus with this invented drying apparatus, water (11) on the surface of wafer (10) can be effectively removed, so wafer (10) can be dried with a high degree of cleanliness. The pressure of the air blown from nozzle (7) can also be lowered, so even when the hood is disposed in a position relatively close to the periphery of fixed base (1), contamination of wafer (10) caused by water that is removed by the blowing of air striking said hood, splashing back, and re-adhering to wafer (10) can be prevented. The result is that making the apparatus larger by disposing the hood at a greater distance from the fixed base will be resolved, and it can be made more compact.

Here, with the aforementioned application example, the nozzle was scanned to remove atomized water on the silicon wafer, but the same effect can also be achieved by moving the fixed base.

In addition to the structure shown in Figures 1 and 2, the drying apparatus related to this invention could also be structured as shown in Figures 3 and 4.

That is, (21) in Figure 3 is a rotary base that has vacuum chuck part (22) at the top. Pipe-shaped shaft (23) is connected at the bottom part of rotary base (21). Shaft (23) is supported by bearing (24). It is rotated at a prescribed speed by motor (25), pulleys (26a) and (26b), which

are attached to shaft (23) and the shaft of motor (25), and by timing belt (27), which is pivotally supported on pulleys (26a) and (26b). Multiple suction pipes (28) are inserted inside aforementioned shaft (23). One end of suction pipe (28) is connected to aforementioned vacuum chuck part (22), and the other end is connected to a vacuum pump, which is not shown, through slip ring (29) that is attached to the bottom end of said shaft (23). A plurality of vibrators (30), for example, five, is also furnished on the reverse surface of aforementioned vacuum chuck part (22). The vibrators (30) are formed from ceramic piezoelectric elements with a resonating frequency of 800 kHz, for example. A cable (31) is connected to each of the aforementioned vibrators (30), and each cable (31) is connected to oscillator (32) through aforementioned shaft (23) and slip ring (29). In addition, supply pipe (33) for supplying pressurized gas (for example, air) is furnished above aforementioned rotary base (21). Here, a cylindrical hood, which is not shown, is furnished around the periphery of aforementioned rotary base (21).

The drying of a silicon wafer, serving as the substrate that has been sliced from a silicon ingot, mirror polished, and has water adhered to the surface after washing with ultrapure water, by the abovementioned drying apparatus shown in Figure 3 will be explained. First, after silicon wafer (34) is mounted on vacuum chuck part (22) of rotary base (21), the vacuum pump (not shown) connected to vacuum pipe (28) is activated and said wafer (34) is suction chucked to said chuck part (22). Next, when 800 kHz high frequency is applied to vibrators (30) through cables (31) from oscillator (32), vibrators (30) vibrate. High-frequency vibration is transmitted to wafer (34) that is vacuum chucked to rotary base (21), and has vibrators (30) disposed on the reverse surface, and water (35) adhered to the surface of said wafer (34) is atomized. In this state, when motor (25) is activated and rotary base (2) is rotated by pulley (26b), timing belt (27), pulley (26a) and shaft (23) while pressurized air is supplied toward wafer (34) from gas supply pipe (33), atomized water on wafer (34) is removed by the centrifugal force and can be dried. At this time, water (35) adhered to the surface of wafer (34) is atomized by aforementioned vibrators (30), so water (35) on the surface of wafer (34) will be removed by rotary base (21) [rotating] at a speed of rotation (for example, 200-500 rpm) that is one magnitude or more slower than the speed of rotation (2000-5000 rpm) of the rotary base in a conventional spin drying apparatus. The pressurized air supplied from gas supply pipe (33) acts to keep the environment above rotating wafer (34) clean for removing and drying the water adhered to the surface of wafer (34) in this way, so the water on wafer (34) can be removed even if the pressurized gas is not supplied. Thus with the drying apparatus shown in Figure 3, water (35) on the surface of wafer (34) can be effectively removed, so wafer (34) can be dried with a high degree of cleanliness. Also, because the speed of rotation of rotary base (1) can be lowered, even if the hood is disposed relatively close to the periphery of rotary base (21), contamination where the water removed by the centrifugal force produced by the rotation of rotary base (21) strikes said hood and splashes back so that it

re-adheres to wafer (34) can be prevented. The result is that making the apparatus larger by disposing the hood at a greater distance from the rotary base will be resolved, and it can be made more compact.

(41) in Figure 4 is a cylindrical fixed base that has vacuum chuck part (42) at the top. Vacuum pipe (43), that communicates with a vacuum pump, which is not shown, is connected to the center of the reverse surface of vacuum chuck part (42) of fixed base (41). A nozzle (44) that can move in the direction of the arrow is furnished above aforementioned fixed base (41). Nozzle (44) is furnished with nozzle unit (45) that is disposed at a desired angle of inclination relative to aforementioned fixed base (41). The pair of opposing side walls of nozzle unit (45), which form a rectangular tube, are tapered, and it has a long, narrow nozzle opening for blowing gas (for example, air) toward the tip of said tapered part. A long, narrow open part is also formed at the top wall on the opposite side from the aforementioned nozzle opening of aforementioned nozzle unit (45), and a vibrator (46) is furnished in said open part. This vibrator (46) is formed from a ceramic piezoelectric element with a resonating frequency of 800 kHz, for example. Aforementioned vibrator (46) is connected to oscillator (48) through cable (47). Gas introduction pipe (49) is connected to the side wall of aforementioned nozzle unit (45). Here, a cylindrical hood, which is not shown, is furnished around the periphery of aforementioned fixed base (41).

The drying of a silicon wafer, serving as the substrate that is sliced from a silicon ingot, mirror polished, and that has water adhered to the surface after washing with ultrapure water, with the abovementioned drying apparatus shown in Figure 4 will be explained. First, after silicon wafer (50) is mounted on vacuum chuck part (42) of fixed base (41), the vacuum pump (not shown) connected with vacuum pipe (43) is activated, and said wafer (50) is suction-chucked to said chuck part (42). Next, when gas (for example, air) is introduced into nozzle unit (45) through introduction pipe (49) of nozzle (44), and 800 kHz high frequency is also applied to vibrator (46) through cable (47) from oscillator (48), vibrator (46) of nozzle unit (45) vibrates, the high-frequency vibration is transmitted to the surface of said wafer (50) using the air blown toward silicon wafer (50) from the long, narrow nozzle opening in said unit (45) as the medium, and the water (51) adhered to the surface is atomized. When nozzle unit (45) is moved from one end above wafer (50) to the other end in this state, atomized water on the surface of wafer (50) can be removed and drying accomplished. At this time, water (51) adhered to the surface of wafer (50) is atomized by the high-frequency vibration using the air from aforementioned nozzle (44) as the medium, so water (51) on the surface of wafer (50) will be removed by the air blown toward said wafer (50) from the nozzle opening of nozzle unit (45) [being] at a pressure (for example 1-3 m/sec) that is one magnitude or greater the high-pressure gas jet (air speed 10-30 m/sec) with a conventional gas knife type. Thus, with this drying apparatus shown in Figure 4, water (51) on the surface of wafer (50) can be effectively removed, so wafer (50) can be dried with a high degree of

cleanliness. Also, the pressure of the air blown from nozzle (44) can be lowered. So even if the hood is disposed in a position relatively close to the periphery of fixed base (41), contamination of wafer (50) due to the water removed by blowing air striking said hood, splashing back, and re-adhering to wafer (50) can be prevented. The result is that making the apparatus larger by disposing the hood at a greater distance from the fixed base will be unnecessary, and the device can be made more compact.

With each of the aforementioned application examples, drying of a wafer that was sliced from a silicon ingot, mirror polished, and washed with ultrapure water was explained, but application in the same way is also possible for drying after washing wafers with ultrapure water in a process for manufacturing a semiconductor device. It is also not limited to silicon wafers, but can be applied in the same way to drying chemical semiconductor materials, for example, GaAs wafers, or InP wafers after washing with ultrapure water, or to drying blank masks themselves or the glass plates that constitute blank masks after washing with ultrapure water. Additionally, application to drying of camera lenses and liquid crystals is also possible.

Effect of the invention

As discussed in detail above, with this invention, it is possible to provide a compact drying apparatus that can sufficiently remove water on a substrate surface to give a high [degree of] cleanliness with this invention, and that can also prevent contamination caused by splash back of water from the hood furnished around the periphery.

Brief description of the figures

Figure 1 is a schematic oblique view of a drying apparatus that shows one application example of this invention. Figure 2 is a schematic cross section of the drying apparatus in Figure 1. Figure 3 or Figure 4 is each a schematic drawing of a drying apparatus that shows another application example of this invention.

(1), (41) … fixed base, (4), (30), (46) … vibrator, (6), (32), (48) … oscillator, (7), (44) … nozzle, (8), (45) … nozzle unit, (10), (34), (50) … silicon wafer, (11), (35), (51) … water, (21) … rotary base, (23) … pipe shaped shaft, (25) … motor.

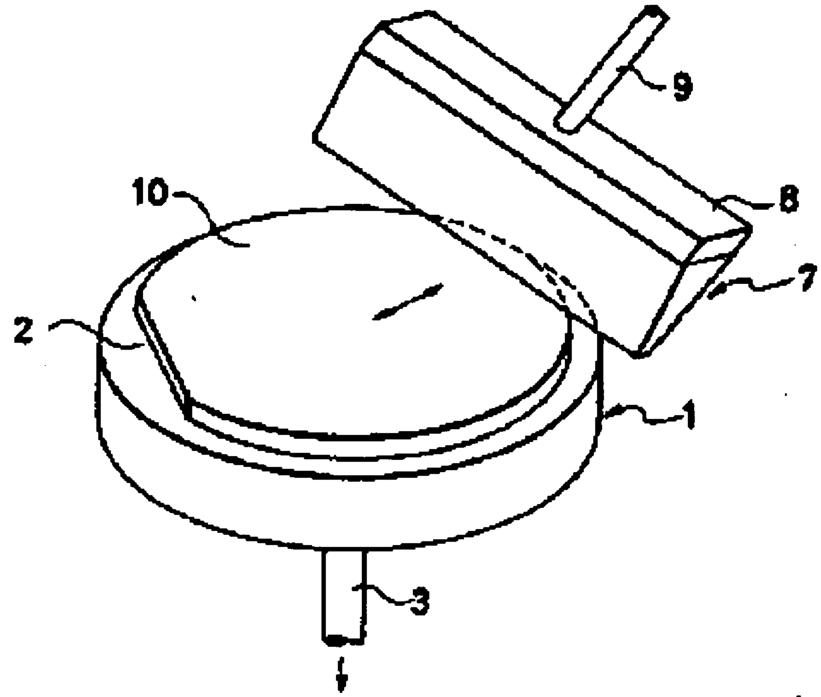

Figure 1

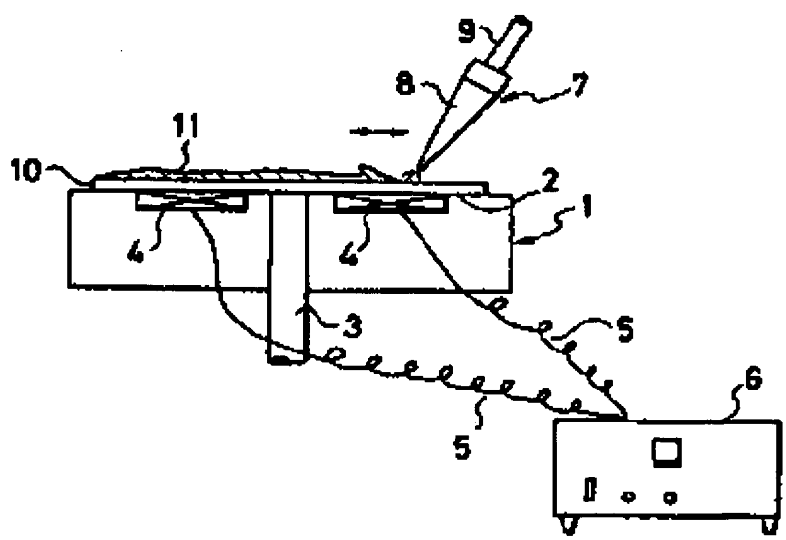

Figure 2

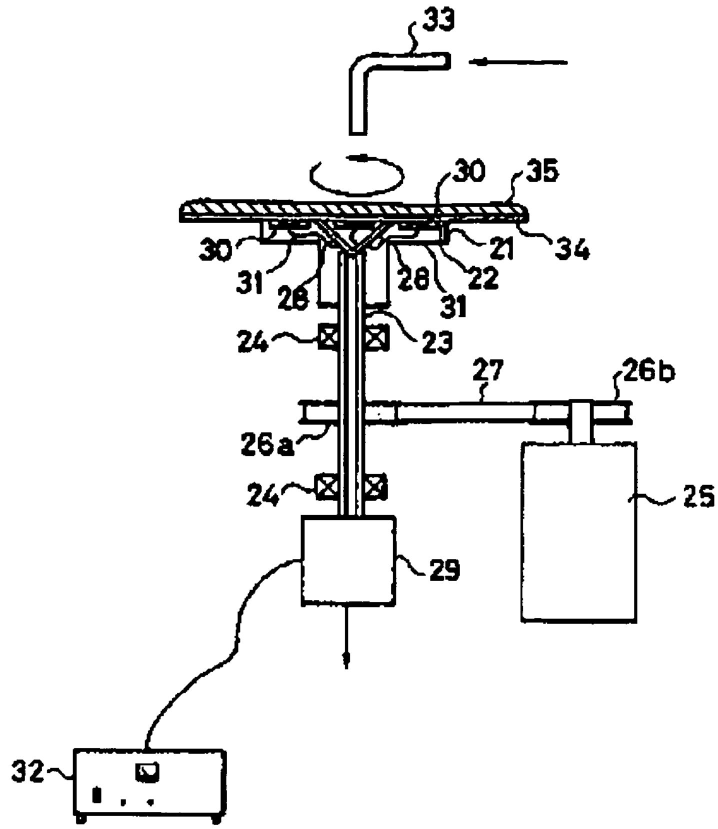

Figure 3

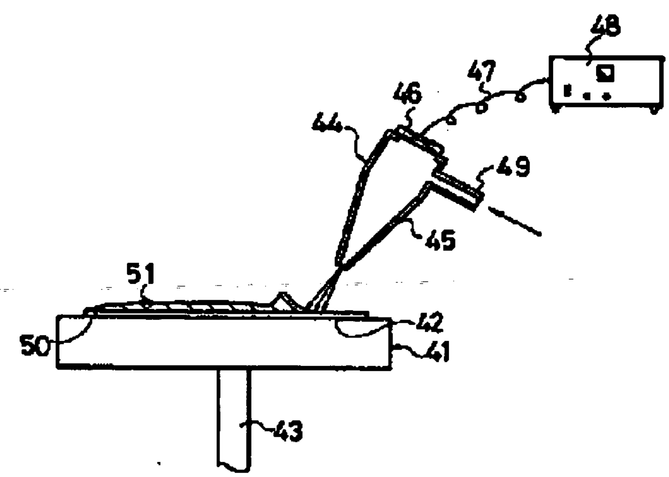

Figure 4